VESA DSC Source Device Guidelines

Background

The VESA Display Stream Compression (DSC) Standard defines a low-latency, visually lossless, constant bit rate image-compression codec that supports various video formats.

A broad range of display transport applications that use DSC have emerged, including:

- Host to one or more displays, possibly through multiple routers
- Automotive Box-to-box Video interconnect
- Mobile- and Automotive-embedded transport links
- AR/VR Headsets connected to a mobile display device

Due to widespread DSC use across various product types, designers need to apply DSC equally well in systems where optimization modes may vary by product and display topology.

This document provides information that might be useful to designers for optimizing systems that apply DSC differently.

Overview and Focus

The scope of this document is to provide DSC Source device designers with information on how to select the best compressed bit rate (i.e., bits per pixel or bpp) for their application. It discusses the tradeoffs between available link bandwidth, system throughput, and power consumption for various applications. While this document is written from a Source device's point of view, some systems allow Sink devices to constrain the compressed bit rate; therefore, DSC Sink device designers might also need to be aware of these tradeoffs.

DSC Compressed Bit Rate Tradeoffs

The DSC codec has several configuration parameters that are defined in a Picture Parameter Set (PPS). The PPS parameters provide information to the decoder about the coded picture and the compression settings used. For example, the *bits_per_pixel* PPS parameter indicates the bit rate that is used to encode the picture. DSC is most often used in a Constant Bit Rate (CBR) mode, where the number of coded bits generated for a slice is always a constant that is generally equal to the bit rate multiplied by the number of pixels within the slice (see *DSC Standard*, Section 3.7.2 [4]). DSC also supports a Variable Bit Rate (VBR) mode that may be used to send fewer bits than the programmed bit rate, when possible. Considerations related to VBR mode are beyond the scope of this document.

There are several factors that may influence which bit rate the encoder might use.

Bit Rate vs. Mean Squared Error

DSC is a lossy codec, meaning that a reconstructed picture might not precisely match its source picture. Increasing the bit rate reduces the mean squared error (MSE), thus increasing the reconstructed picture's peak signal-to-noise ratio (PSNR). Many published studies [1] [2] [3] have concluded that in myriad applications, DSC is visually lossless, meaning that a viewer is unable to distinguish when the compression is active.

Designers are responsible for choosing a bit rate that results in acceptable quality (or MSE) for the target application. Factors that might influence this selection include the pixel density (pixels per degree), complexity and types of the content being encoded, and other application-specific considerations. The chosen bit rate should meet the target application's requirements. Additionally, a transport specification might also enforce its own lower bit-rate limit. For visually lossless quality in typical applications, *DSC Standard* [4] recommends a lower limit of 8 bpp for 4:4:4 mode, 7 bpp for Native 4:2:2 mode, and 6 bpp for Native 4:2:0 mode.

Some designers might choose to increase the bit rate above the acceptable quality level to further reduce the MSE, regardless of whether users will be able to notice a difference. The following sections provide additional information about the tradeoffs involved with increasing the bit rate beyond the acceptable minimum.

Transport Constraints

Transport standards usually specify bit rate constraints for use with DSC.

A transport might put an upper limit on the bit rate for the following reasons:

- To limit the compressed bitstream to the link's available bandwidth.
- To limit the memory required for decoder implementations. A higher bit rate usually means that a larger rate buffer is needed, and that other buffers used for slice multiplexing or handling horizontal blanking might also need to become larger for higher bit rates.

A transport might specify a single bit rate for a particular mode to reduce the compliance testing needed. If a transport allows a range of bit rates, it is implied that more than one bit rate might need to be compliance-tested.

Some transports allow the Sink device to place constraints on the bit rate it receives. This might be achieved through a DisplayID data block structure or similar mechanism.

Encoder Design Considerations

An encoder or Source device designer might choose to constrain the bit rate, even if the transport allows flexibility because some encoder implementations might:

- Support only a subset of DSC bit rates (e.g., no fractional bit rates). This might reduce the testing needed and simplify the design.
- Have buffer size constraints. A rate buffer that is designed to support the minimum bit rate for the most demanding mode might be constrained to a smaller range of bit rates for some other modes.
- Be cost-sensitive. If cost is the primary consideration, a design might support only the minimum bit rate required for a particular mode.
- Be minimizing system power requirements. If reducing the bit rate allows a transport to run at a lower frequency or use fewer lanes, it might be advantageous to reduce the bit rate to conserve power.

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Other Considerations

There might be other system-related considerations related that influence bit rate selection.

- Some systems might convey the same DSC bitstream across different transports. In these cases, the encoder implementation might need to choose a "common denominator" bit rate that is supported by all transports within the display network path. If this is not possible, a transcode might be required.
- Some systems might allow for use of unallocated bandwidth for other purposes. In these systems, it might be desirable to use a lower bit rate to provide for additional bandwidth.
- In some transports, the bit rate is static for a given display stream, while in others, the bit rate may be dynamically changed from picture to picture. In systems that support dynamic bit rates, the optimum bit rate might change depending on the status of the devices within the network topology (e.g., which devices are present, wall plug vs. battery, etc.). Designers should be aware of the display network's nature and that in some cases, the optimal bit rate for the use case may change over time.

References

[1] Allison, Robert S., Laurie M. Wilcox, Wei Wang, David M. Hoffman, Yuqian Hou, James Goel, Lesley Deas, and Dale Stolitzka, "75-2: *Invited Paper* : Large Scale Subjective Evaluation of Display Stream Compression," *SID Symposium Digest of Technical Papers*, Volume 48, Issue 1, 02 June 2017, https://onlinelibrary.wiley.com/doi/10.1002/sdtp.11838.

[2] Hoffman, David M. and Dale Stolitzka. "A new standard method of subjective assessment of barely visible image artifacts and a new public database," *Journal of the Society for Information Display*, Volume 22, Issue 12, 02 June 2015, https://doi.org/10.1002/jsid.297.

[3] Sudhama, Aishwarya, Matthew D. Cutone, Yuqian Hou, James Goel, Dale Stolitzka, Natan Jacobson, Robert S. Allison, and Laurie M. Wilcox, "85-1: Visually Lossless Compression of High Dynamic Range Images: A Large-Scale Evaluation," *SID Symposium Digest of Technical Papers*, Volume 49, Issue 1, 30 May 2018, https://onlinelibrary.wiley.com/doi/10.1002/sdtp.12106.

[4] Video Electronics Standards Association (VESA), *VESA Display Stream Compression (DSC) Standard* (*DSC Standard*), Version 1.2a, 18 January 2017.

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